The first adjustment is to compare CDMA and GSM outputs at power levels and operating modes defined by U.S. standards.[7] The chart on page 4 of the July 1995 Report, *Range of Audible Interference (1900 MHz)*, even though it measures a non-standard 200 milliwatts CDMA phone, indicates that the CDMA phone in the U.S. standard variable rate vocoder mode generates audible interference for a range of approximately 0.1 meter (*i.e.*, approximately four inches) to approximately 1.3 meters (*i.e.*, slightly more than four feet).[8]

Another important adjustment involves system power control. In the Conclusion of its July 1995 Report, Qualcomm states, "In normal operation, where all CDMA phones are subject to system power control, transmit power levels vary, averaging 10 to 20 [milliwatts] of peak output power. Measurements made at 20 [milliwatts] indicate the radiating antenna must be within 2 to 13 cm (1 to 5 inches) for audible interference to be detected in hearing aids."[9] But then Qualcomm continues, "[c]onversely, a GSM TDMA portable

---

[7] Consequently, the test data shown on pages 1-3, the top of page 4, page 5, and the top of page 6 do not pertain to the U.S. application of GSM and CDMA technologies.

[8] There is no U.S. standard for a locked full rate vocoder.

[9] July 1995 Report at 6.

in normal operation transmits at a nominal peak power level of 2 watts (1 watt at 1900 MHz). Tests showed that a GSM portable located within a distance of 1 to 3.5 meters from a hearing aid would cause audible interference."[10] Qualcomm fails to mention that GSM phones also operate under system power control with an operating range of 1 milliwatt to 1.0 watt. Unlike their reference to CDMA phones, Qualcomm provides no data for GSM phones operating under system power control. As the attached chart demonstrates, under the power levels established by the U.S. standard for PCS 1900 phones, power levels below 20 milliwatts also predominate.

When these adjustments are made, as Qualcomm has demonstrated in earlier studies, both CDMA and GSM phones at similar power levels can create audible interference within a range of detectability that is nearly equal.[11]

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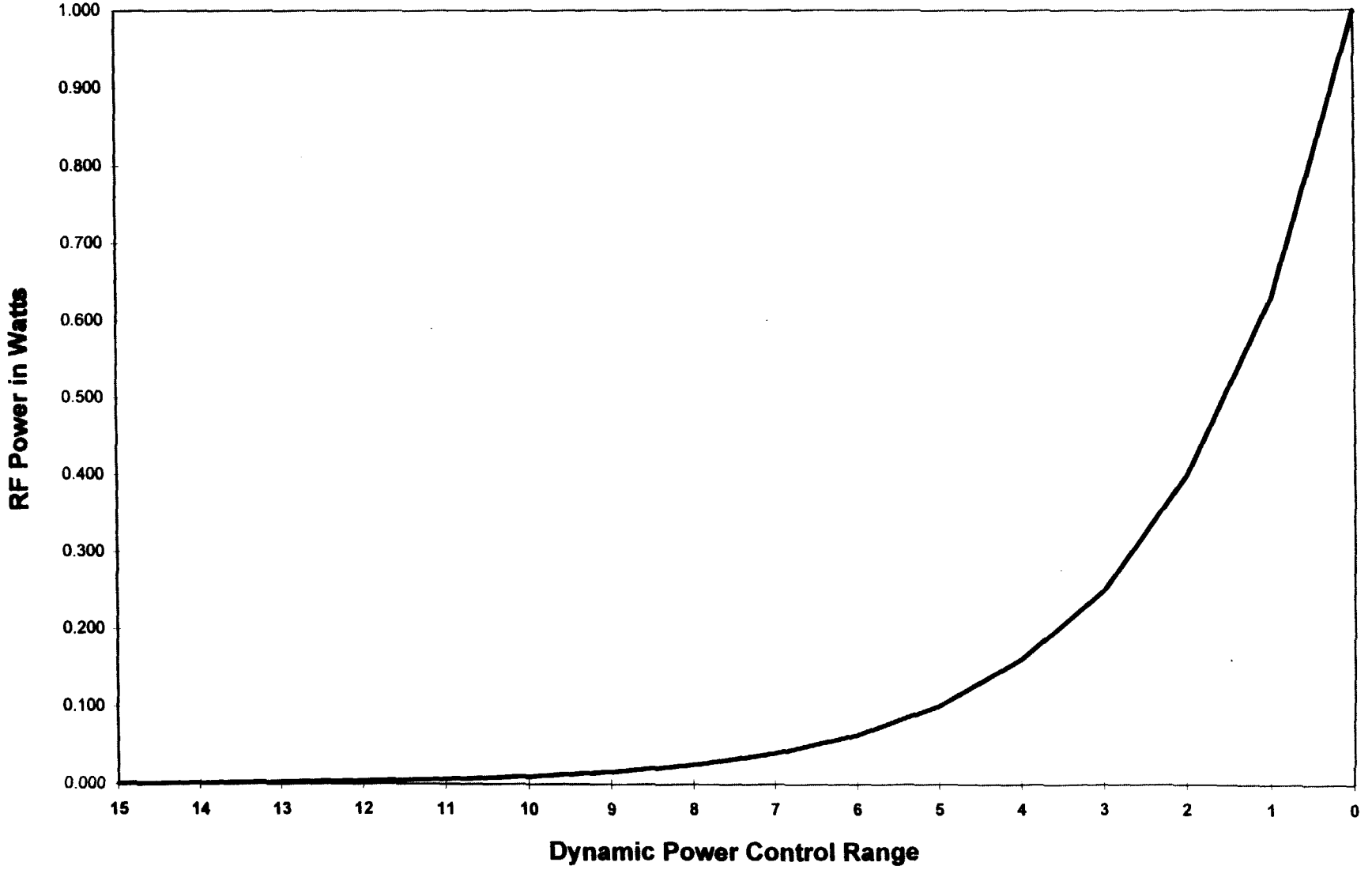
[10] July 1995 Report at 7.

[11] For example, at identical 200 milliwatt power levels, a hearing impaired listener with a Phonak PE 845 hearing aid could detect interference from a CDMA phone at 25 cm (9.8 inches), while the same listener could detect interference from a GSM phone at 30 cm (11.8 inches). In this same test, interference was judged as becoming "annoying" at 8 cm (3.1 inches) for the CDMA phone, compared to 14 cm (5.5 inches) for the GSM phone.

Handheld Class 1 PCS1900 GSM Power Levels



APPENDIX B

PROTOCOL FOR THE STUDY OF HEARING AID INTERACTION WITH WIRELESS PHONES

Version 2.0

CENTER FOR THE STUDY OF WIRELESS ELECTROMAGNETIC COMPATIBILITY

SCHOOL OF INDUSTRIAL ENGINEERING
UNIVERSITY OF OKLAHOMA

July 25, 1995

INTRODUCTION

This protocol has been developed in support of a study, on the interaction between various types of wireless telephones and hearing aids to be conducted at the University of Oklahoma. The overall purpose of the study is to objectively and subjectively, evaluate the interference between wireless phone technology and hearing aids. The Phase I objectives of the study are to:

1. define the test protocol for physical measurement of the interference generated in hearing aids by wireless phone signals of varying types. The resulting protocol shall produce repeatable results and include parameters such as field strength, threshold distance of interference, and intensity and frequency of the resulting audio interference output;
2. define a standard methodology for measuring the immunity of hearing aids, including standards for acceptable "noise floors"; and
3. define the test protocol for subjective measurement of the extent of the interference generated in hearing aids by wireless phone signals of varying types. The protocol shall include the use of both hearing-impaired and unimpaired individuals.

Background

This protocol is based on input from the references listed at the end of this document and from members of the Hearing Aid Wireless Phone Interaction Study Design Group. Much of the protocol is based on a study conducted by the National Acoustic Laboratories, a division of the Australian Hearing Services (Le Strange, Byrne, Joyner, and Symons, 1995).
European and Australian clinical and laboratory studies have demonstrated that audible interference ("buzzing") can be produced in hearing aids by hand-held wireless phones operated in close proximal, (a few centimeters to several meters). This effect has been demonstrated in the US but little has been published in terms of research results. This protocol encompasses both physical measurement of hearing aid interference (objective testing) and how this interference is perceived by hearing aid users (subjective testing). The model outlined by Bowen (1995) identifies one possible breakpoint that connects the objective and subjective testing. Physical testing involves the RF source, RF path, and the hearing aid (objective). Output from the hearing aid is acoustically coupled to the user who develops a perception of the interference signal (subjective). Objective and subjective tests can be independent.

PROTOCOL FOR THE STUDY OF HEARING AID INTERACTION WITH WIRELESS PHONES

CURRENT RESEARCH

Currently reported studies in Europe and Australia have examined the interference generated by GSM phones, the predominant wireless phone technology outside of the US. GSM uses a Time Division Multiple Access (TDMA) signal structure as do most digital wireless phones in the US. The TDMA principle results in the carrier being pulsed in a fashion that allows audio frequency devices (hearing aids, portable stereos, etc.) to demodulate the radio frequency (RF) envelope and produce a constant, distinctive buzzing sound. According to reports, these TDMA signals

interfere with hearing aids from as far as 30 meters depending on the hearing aid model. At a range of 3 to 5 meters, hearing aid users may experience a 200 Hz humming noise overpowering all other signals. This is a particular problem for hearing aid wearers who wish to use wireless phones. The degree of interference immunity varies widely by hearing aid type with the in-the-ear (ITE) devices typically having higher immunity. The level of interference is also affected by the relative orientation of the hearing aid and the phone.

Physical Measurements

Quantification of the sensitivity of a particular hearing aid (HA) to wireless phone interference is the first step in the ultimate development of immunity standards. Physical testing of HA immunity requires an RF signal source for generation and propagation of the appropriate cell phone signal, a controlled RF environment, a means for mounting and orienting the HA, and instrumentation for measuring the level of the audio interference output.

RF Test Signal

Previous researchers have employed various RF test signals to represent the GSM RF signal, including:

1. 900 MHz pulse modulated carrier with a modulation frequency of 217 MHz duty cycle of 1:8 and 100% modulation (EHIMA, 1993; Joyner et al., 1993;
National Telecom Agency of Denmark, 1994), and
2. a 900 MHz carrier, 80% modulated by a 1000 MHz sine wave (IEC, 1994; Le Strange et al., 1995).

No reports have been located in which the physical measurement testing was conducted using actual wireless phones. Some subjective testing has been reported with actual phones (Le Strange et al., 1995).

This study will use actual wireless phones. Some models will be "hot wired " or programmed in a continuos transmission mode. Other models will communicate with an HP 8920A RF Communications Test Set functioning as a base station simulator. This approach provides the greatest realism in terms of actual signal structure including the format for control and voice traffic (e.g., paging, power control, channel changes). This approach requires an accurate means of measuring RF field intensities generated by the phones at various distances.

RF Environment

Previous researchers have employed or compared various RF test environments, including:

1. a radio frequency anechoic room (EHIMA, 1993; IEC, 1994; Le Strange et al., 1995),
2. "stripline" consisting of a ground plane, stripline conductor, and 50 ohm resistive matching network (EHIMA, 1993), and
3. a waveguide (Joyner et al., 1993; Le Strange et al., 1995).

RF field intensities have either been fixed at 10 V/m or varied up to 200 V/m.

None of the three previously used RF test environments have been selected for this study. Options 2 and 3 are precluded by the fact that actual phones along with their self-contained antennae will be used as the signal source. Testing will be conducted at

the AT&T Open Area Test Site (OATS) In Oklahoma City. A radio frequency anechoic room (Option 1) is not currently available at this facility. Therefore, testing will be conducted within the shielded room at the OATS facility. The possibility of using a GSM cell will also be explored.

Mounting and Orienting the Hearing Aid

The hearing aid must be positioned in the RF test field away from objects that could distort the field and in such a way that it can be manipulated for maximum interference. Previous protocols have used the following:

1. place HA in chamber in "normal use" position, rotate (clockwise) in 90° steps in the horizontal plane, measure interference at maximum SPL (EHIMA, 1993; IEC, 1994; National Telecom Agency of Denmark, 1994),
2. use both horizontal and vertical polarization of the RF field (EHIMA, 1993),
3. gimbal style mounting device for positioning HA in the waveguide about three axes, rotate for maximum pickup (Le Strange et al., 1995), and
4. mount within the Kemar head (no reference found at present).

Discussions of the Study Design Group led to the conclusion that the Kemar head (Option 4) was not an effective means of mounting the hearing aids since it did not provide a good RF analog of the human head. Option 3 is unique to the waveguide approach which is not being used in this study. Options 1 and 2 will be combined through the user of a non-RF distorting mounting device for alignment of the HA and a *device for positioning of the phone.*

Measuring Hearing Aid Output

The output of the HA must be measured without introducing instrumentation that could distort the RF field. This has typically been accomplished by using small diameter (2 mm) plastic tubing with a length between 50 mm and 500 mm to distance the HA and the acoustic monitor (IEC, 1994). Specific examples include:

1. ear simulator (IEC 711)to audio test station, amplifier, and DAT recorder via 500 mm tubing (EHIMA, 1993; National Telecom Agency of Denmark, 1994), and
2). standard 2 cc acoustic coupler to measuring microphone (B&K4155) and measuring amplifier (B&K 2636) via 500 mm length of 2 mm Tygon© tubing (Le Strange et al., 1995)

Option 2 will be used in this study based on available models of audio monitoring equipment.

Subjective (Psycho-acoustic) Measurements

Subjective evaluation of wireless phone interference is important since the delectability and annoyance of the interference depend on the individual hearing acuity of each HA user. Delectability and annoyance levels should be determined for hearing-impaired people with hearing losses appropriate to each type of HA. Persons with normal hearing should also be included to represent worst case situations of delectability and annoyance. Delectability can be determined through the application of standard psychophysical techniques such as the method of limits or method of constant stimuli. The degree of annoyance is typically ascertained through the use of subjective scaling techniques.

Interference Source

Subjects may be presented with either actual or recorded interference signals. Specific examples include:

1. recorded interference signal together with pinknoise, "partysounds", or connected speech (EHIMA, 1993; National Telecom Agency of Denmark, 1994),

and

2. actual phone with call placed to pre-recorded message (Le Strange et al., 1995). A variation of Option 2 can be achieved through the use of the base station simulator and the cell phone loopback (talkback) mode or audio transmission from the base station.

Detectability

Interference can be recorded on DAT or generated directly with actual phones for evaluation of detectability. Any of the following schemes can be used:

1. samples of various levels of recorded interference can be replayed in random sequence at random intensity levels while subjects are asked to respond as to the presence or absence of interference,
2. subjects wearing hearing aids are tested by moving an actual phone across a number of test sites from far (4 m) to near and back while the subject indicates the presence or absence of a "buzz" (Le Stranize et al., 1995), and
3. subjects can listen through tubing to actual hearing aid output with the HA at various locations (e.g., close to phone as in listening to a call, one meter, and up to several meters). The acoustic level of interference is classified as: "not preceptible", "just perceptible", 'moderately perceptible", and "annoyingly perceptible" (Le Strange et al., 1995).

Annoyance/Usability

The interference signal is presented at random intensity levels and,/or varying distances while subjects are asked to respond with the corresponding level of annoyance. Examples of the scales used include:

1. "not annoying", "slightly annoying", "annoying", and "very annoying " (EHIMA, 1993), and
2. "usable", "sometimes usable", and "unusable" (Le Strange et al., 1995).

Tests for Detectability, and Annoyance will *be combined using a hybrid mixture of Options 2 and 3 above under detectability. This provides a more authentic test for the extent of the problem as determined by subjects listening to the actual interference.*

Experimental Variables

The experimental variables in the study consist of the independent variables which are manipulated, dependent variables which are measured, and control variables. The control variables are defined by the test environment ("test bed"), test apparatus and experimental procedure. The dependent variables include the physical measurements and characteristics of the interference levels and immunity "scores", and the subjective responses for delectability and annoyance. The independent variables represent those factors which are tested to determine their influence on the dependent measures (both objective and subjective). Potential factors in this study are presented in outline form in the following section labeled Experimental Design.

EXPERIMENTAL DESIGN

FACTORS AND LEVELS

Hearing Aids

Hearing aid types

Behind the ear (BTE)
In the ear (ITE)
In the canal (ITC)
Completely in canal (CIC)
(ITE, ITC and CIC comprise 80% of market)

New devices vs. current patients

Specific manufacturers, models, units/model (too many?)

Phones

Phone technology (in priority order)

1. TDMA (D-AMPS) @ 800 MHz (IS-54) and 1900 MHz (IS-136)
2. CDMA @ 800 MHz (IS-95) and 1900 MHz (J008)
3. PCS @ 1900 MHz (J007)
4. GSM @ 900 MHz
5. GSM @ 1900 MHz

Participating manufacturers

Test Procedure Variables

Distance between phone/simulator and HA

Side of head

Ipsilateral (same side) vs. contralateral (opposite side)use
(important because of Class I vs. Class II standards)
Phone use by others vs. phone use by HA wearer

Relative orientation

Antenna position/field polarization
Angle of coupling (HA orientation)

REFERENCES

EHIMA (October 1993). *EHIMA GSM Project Development Phase,* Project Report (Revision A). Wemmel, Belgium: European Hearing Instrument Manufactures Association.

ETSI (February 1993). *GSM EMC Considerations,* ETSI Technical Report GSM 05.90 Version 4-0.0. Valbonne Cedex, France: European Telecommunications Standards Institute.

IEC (May 994). First lEC/CD 118-XX- Hearing aids Part XX: Electromagnetic compatibility for hearing aids - Immunity *to radio frequency fields* .

Joyner, K.H., Wood, M., Burwood, E., Allision, D., and Le Strange, R. (March 1993).

Interference to Hearing Aids by the New Digital Mobile Telephone System, Global System for Mobile Communications Standard. Sydney, Australia: National Acoustic Laboratories, Australian Hearing Services,

Le Strange, J.R., Byrne, D., Joyner, K.H., and Symons, G.L. (May 1995). *Interference to Hearing Aids by the Digital Mobile Telephone System. Global Svstem for Mobile Communications (GSM),* NAL Report No. 131. Chatswood, New South Wales, Australia: National Acoustic Laboratories, Australian Hearing Services.

National Telecom Agency of Denmark (June 1994). *Interference with hearing aids caused by GSM digital wireless telephones and DECT digital cordless telephones* Denmark: National Telecom Agency.

Short, J. (1992). EMC considerations for digital cellular radio and hearing aids (journal?) Ipswich, England: BT Laboratories.

CERTIFICATE OF SERVICE

I, Andrea D. Williams, hereby certify that on this 1st day of August, 1995, copies of the foregoing Reply Comments of the Cellular Telecommunications Industry Association were served by hand delivery upon the following parties:

Mr. William Caton
Secretary
Federal Communications Commission
1919 M Street, N.W., Room 222
Washington, D.C. 20554

International Transcript Service
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Andrea D. Willams

CERTIFICATE OF SERVICE

I, Andrea D. Williams, hereby certify that on this 1st day of August, 1995, copies of the foregoing Reply Comments of the Cellular Telecommunications Industry Association were served by first class mail upon the following parties:

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Randall S. Coleman
Vice President for Regulatory Policy and Law

August 2, 1995

The Honorable Rachelle B. Chong
Commissioner
Federal Communications Commission
1919 M Street, NW - Room 844
Washington, DC 20554

Re: Section 68.4 (a) of the Commission's Rules: Hearing Aid Compatible Telephones (RM-8658)

Dear Commissioner Chong:

For your convenience and information, attached is a copy of CTIA's Reply Comments in response to the Petition for Rule Making to amend Section 68.4 (a) of the Commission's Rules filed by Helping Equalize Access Rights to Telecommunications Now (HEAR-IT NOW). These Reply Comments demonstrate that the majority of commenting parties:

- agree that the HEAR-IT NOW petition asks the Commission to reverse its course and slow down the roll out of broadband PCS in the United States, and thereby delay the additional competition and investment in new wireless technologies;

- concur that a rule making to limit or revoke the exemption of PCS devices from the Commission's hearing aid compatibility requirements is inappropriate, particularly when joint efforts by the PCS and hearing aid industries are underway to address and resolve electromagnetic compatibility (EMC) issues; and

- support a denial of the petition and ask the Commission to allow the affected industries to continue their research and make appropriate recommendations to define and resolve the EMI issues.

This consensus and the recommended conclusion is strengthened by the fact that the evidence presented in support of the Petition is insufficient and, in some cases, mischaracterized.[1]

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[1] *See* CTIA Reply Comments at 4-7 and Technical Appendix.

The allegations made concerning GSM technology cannot be considered in a vacuum. In your review of the record, CTIA urges you to keep in mind the following:

1. Without government intervention, the wireless industry has and continues to respond to the challenge of ensuring accessibility to wireless telecommunications services for the hearing impaired. Should the Commission mandate a uniform solution, *e.g.*, t-coil compatibility, for all wireless devices, wireless operators would not have the flexibility to implement multi-faceted approaches to ensuring accessibility for the hearing impaired.

2. It is unknown whether existing or planned CDMA phones are hearing aid compatible as defined by Part 68 of the Commission Rules, *i.e.*, they include a flex coil for magnetic coupling with a t-coil hearing aid.

3. While it has been asserted that CDMA phones do not interfere with hearing aids, the developer of CDMA technology says they can.[2]

4. If it were determined that interference from CDMA phones could not be completely eliminated, would supporters of the HEAR-IT NOW Petition advocate that CDMA phones be banned? Moreover, would supporters of the Petition advocate the Commission adopting technical standards for broadband PCS, whereby specific power limitations and the redesign of the transmission portion of all wireless digital telephones, including CDMA phones, are required to eliminate interference?

Viewed in the proper context, the allegations against GSM technology and the unknowns with respect to CDMA technology should lead the Commission to conclude that the transition to digital wireless technologies presents EMC issues which must be addressed. However, the resolution of EMC issues do not warrant regulatory choice between technologies, particularly when the affected industries are addressing and resolving such issues. The wireless telecommunications industry is committed to making its services accessible to all Americans. As the Commission has acknowledged throughout the PCS rule making, auction and licensing processes, it is the competitive marketplace that should determine winners and losers, not the government.

Yours truly,

Randall S. Coleman

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[2] In its Comments, Qualcomm indicates that CDMA phones at 200 milliwatts can interfere at distances from 4 inches to four feet. *See* CTIA Reply Comments, Technical Appendix at 5.

cc: Ms. Jill Luckett
Attachment

STAMP + RETURN

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	
Section 68.4(a) of the Commission's Rules	)	RM-8658
Hearing Aid Compatible Telephones	)	
	)	

REPLY COMMENTS OF THE CELLULAR TELECOMMUNICATIONS INDUSTRY ASSOCIATION

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August 1, 1995

TABLE OF CONTENTS

SUMMARY

The wireless industry has and continues to demonstrate its commitment to ensuring access to wireless telecommunications services for all Americans. The Hearing Aid Project at the Center for the Study of Wireless Electromagnetic Compatibility, analog phones, and the HATIS device are manifestations of that commitment to ensure accessibility to the hearing impaired.

The majority of the commenters support a denial of the HEAR-IT NOW Petition and ask the Commission to allow the affected industries to define and resolve the EMI issue. They acknowledge that a rule making is inappropriate, in view of the industry efforts to address the EMC issues and the insufficient evidence presented by the Petitioner.

In this Reply, CTIA responds to Qualcomm's tests conducted on EMI between hearing aids and CDMA and GSM telephones; HIA's mistaken assumption that shielding is not an effective solution; and the incorrect assumption that the Part 68 HAC requirement is an appropriate method for providing compatibility and hence accessibility to wireless digital telephones.

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	
Section 68.4(a) of the Commission's Rules	)	RM-8658
Hearing Aid Compatible Telephones	)	
	)	

REPLY COMMENTS OF
THE CELLULAR TELECOMMUNICATIONS INDUSTRY ASSOCIATION

The Cellular Telecommunications Industry Association ("CTIA")[1] hereby submits its Reply Comments in response to the Petition for Rule Making to amend Section 68.4(a) of the Commission's Rules filed by Helping Equalize Access Rights in Telecommunications Now ("HEAR-IT NOW").[2]

I. Introduction

The wireless industry has and continues to demonstrate its commitment to providing all Americans, both the hearing abled and hearing impaired, with access to wireless telecommunications services. Although Congress exempted the wireless industry from hearing aid compatibility requirements

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[1] CTIA is the international organization of the wireless communications industry for both wireless carriers and manufacturers. Membership in the association covers all Commercial Mobile Radio Service providers, including cellular, personal communications services, enhanced specialized mobile radio, and mobile satellite services.

[2] *In the Matter of Section 68.4(a) of the Commission's Rules Hearing Aid Compatible Telephones,* Petition for Rule Making, filed June 5, 1995 ("Petition").

("HAC requirements"), the industry, without any government intervention, has responded to the challenge of ensuring that hearing aid users have access to wireless telephones. Even without a government mandate, the industry currently provides devices which make wireless telephones accessible to hearing aid users, *i.e.*, analog telephones, HATIS device.[3]

In addition, the wireless industry has undertaken an extensive research program in conjunction with hearing aid manufacturers to address the electromagnetic compatibility between hearing aids and all U.S. digital wireless telephones, *i.e.*, CDMA, PCS 1900, and TDMA.[4]

In conjunction with the wireless industry's efforts, hearing aid manufacturers already have provided hearing aids, *i.e.*, those with a high immunity level, that are compatible with wireless digital telephones, thereby promoting accessibility for hearing aid users.[5]

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[3] AT&T, Ericsson, Fujitsu, Motorola, Nokia and Oki offer wireless phones with HATIS-compatible jacks. AT&T, NYNEX, McCaw, BellSouth, Bell Atlantic and Motorola plan to sell the HATIS device as a telephone accessory. Garrett, *Ready, Willing and Able,* HOME OFFICE COMPUTING, June 1995, at 112.

[4] *See* CTIA Comments, Exhibits 2-4, Hearing Aid Project, Center for the Study of Wireless Electromagnetic Compatibility at the University of Oklahoma. *See also* Appendix B, *Revised Protocol for the Study of Hearing Aid Interaction with Wireless Phones,* Version 2.0 (July 25, 1995).

[5] *See* J. Le Strange, E. Burwood, D. Byrne, K. Joyner, M. Wood, & G. Symons, *Interference to Hearing Aids*

Many of the commenters agree that the HEAR-IT NOW petition asks the Commission to reverse course and slow down the introduction of broadband PCS in the United States, and thereby delay the additional competition and investment in new wireless systems and technologies.[6] The majority of the commenters concur that a rule making to limit or revoke the exemption is inappropriate, particularly when inter-industry efforts are underway to address and resolve the electromagnetic interaction ("EMI") issues,[7] and the evidence presented by the Petitioner is insufficient and in some instances, mischaracterized.[8] Accordingly, these commenters,

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by the Digital Mobile Telephone System, Global System for Mobile Communications,(GSM), NAL Report No. 131, National Acoustic Laboratories, Sydney, Australia, iii (May 1995) ("1995 Australian Study").

[6] American Personal Communications ("APC") Comments at 2, 11, 15; BellSouth Corporation ("BellSouth") Comments at 3-10; CTIA Comments at 26-29; GSM MOU Association ("GSM MOU") Comments at 1-2, 15; Northern Telecom, Inc. ("Nortel") Comments at 1, 3; Personal Communications Industry Association ("PCIA") Comments at 4; Siemens Stromberg-Carlson ("Siemens") Comments at 2.

[7] APC Comments at 9-11; BellSouth Comments at 10-11; CTIA Comments at 11-15; The Ericsson Corporation ("Ericsson") Comments at 7-8; GSM MOU Comments at 18-20; Nokia Mobile Phones, Inc. ("Nokia") Comments at 2; Nortel Comments at 3-4; Pacific Bell Mobile Services ("Pacific Bell") Comments at 2; PCIA Comments at 3-4; Southwestern Bell Mobile Systems, Inc. ("SBMS") at 4-5; Siemens Comments at 2; Telecommunications Industry Association ("TIA") Comments at 2-3.

[8] APC Comments at 5-9, 11-13; CTIA Comments at 17-24; Ericsson Comments at 2, 9-10; GSM MOU Comments at 4-11; Nortel Comments at 4-5; Pacific Bell Comments at 2; PCIA Comments at 2; SBMS Comments at 2-3; Siemens Comments at 1-2.